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ABSTRACT

This Occasional Paper uses historical and recent concerns about mathematics and science content standards to demonstrate conflict and tensions that surround the process of setting standards. The tension between flexible and specific standards is analyzed. No simple recipe will resolve differing viewpoints, but this Occasional Paper analyzes key actors and provides guidance for reaching consensus. While subject matter specialists are an important component of any resolution, this Occasional Paper stresses the multiple perspectives that must be considered. (Contains 19 references.) (Author/YDS)

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Abstract

This Occasional Paper uses historical and recent concerns about mathematics and science content standards to demonstrate conflict and tensions that surround the process of setting standards. The tension between flexible and specific standards is analyzed. No simple recipe will resolve differing viewpoints, but this Occasional Paper analyzes key actors and provides guidance for reaching consensus. While subject matter specialists are an important component of any resolution, this Occasional Paper stresses the multiple perspectives that must be considered.

Introduction

Significant progress has been made in recent years toward the furthering of nationwide systemic reform in kindergarten through 12th-grade mathematics and science education. The Curriculum *and* Evaluation *Standards* of the National Council of Teachers of Mathematics (1989) and NCTM's subsequent sets of standards on teaching and assessment are guiding mathematics reform around the nation. The *Benchmarks* document produced by Project 2061 (American Association of the Advancement of Science, 1993) and the comprehensive statements regarding science education in the *National Science Education Standards (NSES)* published by the National Research Council (1996) are more recent but rapidly becoming influential in science education. These standards documents have achieved high visibility among science and mathematics educators and among education policymakers more generally. Evidence of increased activity at the state level, one critical key to thorough reform, is especially heartening to organizations embracing the idea that only through a coherent coast-to-coast effort can the nation's elementary and secondary mathematics and science curricula serve all students in our increasingly technological society. Many professionals would like to think that making curriculum decisions is apolitical, but in fact the process is essentially a political one, with high stakes for students and many other constituencies.

That the political pressure for accelerated progress is intensifying was made clear at a national education summit held in March, 1996, in Palisades, New York. The summit was attended by 40 governors and 49 corporate executives. The governors committed to developing and establishing internationally competitive academic standards, assessments to measure these standards, and accountability systems in each of their states-all within the next two years. The governors and business leaders believe that, to improve students' academic performance, states and local school districts must develop a consensus on what children should know and be able to do, though they recognized during the summit meetings that building such consensus will be difficult. They further committed to creating an external independent, nongovernmental entity to facilitate their work on content standard setting, aligned assessments, and accountability.

Those who seek to develop strong, wide-spread, supportive coalitions for new mathematics and science content standards must be prepared for the rigors and demands of the political process. Building successful coalitions means bargaining with people and groups representing different agendas and interests, while trying to remain true to a vision of what content standards should be. It means encountering opposing points of view, based on values held deeply by disparate groups. Even though such conflicts can be papered over in general reform statements and documents, they simply cannot be resolved to everyone's satisfaction once implementation of reform takes place in the classroom in the form of specific curricula, instructional practices, and student assessment. This means that reformers must learn the political landscape and develop strategies for how to proceed (Kirst, 1994).

A New Vision, New Challenges

Traditionally, the development of curriculum has been left to textbook writers, often one individual or a small group. School boards or national subject-matter associations might set

general curriculum policy, but these groups frequently work in ways that result in only small changes at the margins, excluding curriculum policy alternatives deemed too radical. Often they seek to avoid conflict by describing content standards only in vague language and by covering so many topics that no interest group feels left out. Content depth is thereby lost to political expediency.

The *National Science Education Standards (NSES)* illustrates the complex politics of systemic reform. This standards document is designed to enable the nation to achieve the goal of scientific literacy for all students. Nine major science and science education organizations as well as hundreds of other groups and thousands of individuals contributed to shaping *NSES* through cycles of review and revisions over almost five years. Following the introduction of several unifying concepts and processes of science appropriate for students at all grade levels such as "evidence and models," "systems and organization," and "evolution and equilibrium," the science content standards are grouped for grades K-4,5-8, and 9-12. The standards are organized around inquiry, including the abilities necessary to do and understand scientific inquiry; the three traditional school subjects of physical science, life science, and earth and space science; science and technology, including abilities of technological design and understanding about science and technology; science in personal and social perspectives including, for example, personal and community health, natural resources, and environmental quality; and the history and nature of science dealing, for example, with science as a human endeavor and the nature of scientific knowledge. With an emphasis on student understanding, inquiry, technology, and the application of science beyond the classroom, the content standards of *NSES* cover much subject matter not found in existing textbooks. Recognizing that changing the content of school science is not sufficient to support reform, the *NSES* document also includes standards for teaching and the professional development of teachers, for assessment of student learning, for programs (recommending changes at the school and district level), and for systems (suggesting procedures at levels beyond the school district).

Despite the extended and public nature of the development of the NCTM mathematics standards and the NRC science standards, they have generated significant conflict and resistance. Some view the absence of familiar topics as removing the rigor from the mathematics and science curriculum and discarding of the basics for the newly "fashionable." Some criticize the documents as superficial and unhelpful since they do not include details of sequence and organization necessary for direct classroom implementation. Others see the *NSES*, especially those standards going beyond the traditional subject matter of physical, life, and earth/space science, as imposing particular values on the schools that are not necessarily held by the majority of the community.

Still others believe that neither *Benchmarks* with its 855 entries (given that many build on each other) nor *NSES* with its 77 separate learning goals has yet addressed the problem of reducing content coverage in favor of in-depth study of a few key concepts (Raizen, 1997). And even though there is an 80 to 90 percent overlap in science content coverage between the two documents, their separate existence has proved somewhat confusing. Already, externally designed tests used for district accountability and university admissions are strongly influenced by breadth of subject matter knowledge rather than depth of understanding and application; the

inclusivity of both the NRC and the Project 2061 science standards may just aggravate some of the negative aspects of current tests.

Yet another problem is that there are few existing curriculum materials that support inquiry-based instruction and fewer that are clustered by grades K-4,5-8 and 9-12. Engaging students in scientific inquiry is expensive and requires different time allocations than are currently found in most schools. Including science in the elementary grades requires a major alteration in the school program. When students are involved in group work, as the *NSES* suggests, it is more difficult to evaluate the progress of individual students, and often the parents of higher-achieving students resist their children "wasting time" in group activities.

A Turbulent History

The type of controversy over curriculum reform sparked by today's standard setting in mathematics and science is not new (Schaffarzick & Sykes, 1979). To see that curriculum reform in the United States has long been politically charged and subject to multiple influences, one need only examine the history of school mathematics reform in the 1960s.

Curriculum reform in science and mathematics predated the Soviet Union's launch of Sputnik in 1957. Critics of U.S. education seized on this event to proclaim that America's "defeat" in the space race was attributable to poor schooling (Raizen, 1991). This issue quickly became part of the national political agenda. Mathematicians and mathematics educators fastened on the goal of raising mathematics comprehension and sought to introduce a new way of thinking about mathematics, based on understanding the underlying structures of mathematics rather than the rote learning of algorithms. Concepts new to the school curriculum such as set theory were featured. Federal money was targeted at developing and. implementing new mathematics curricula, training high school mathematics teachers to (deliver them, and incorporating relevant changes into schools of education. States endorsed and further funded these efforts, and state agencies strengthened their mathematics curriculum divisions and their efforts to help implement change. Soon, what had started as an effort aimed at secondary education moved into the elementary grades, but without the extensive teacher inservice opportunities provided to secondary teachers.

Thousands of local education agencies adopted the new mathematics curriculum goals. As a result, millions of students were exposed to new mathematical concepts and understood them reasonably well where teachers were adequately prepared. But the "new math" was far from universally popular. Critics charged that the curriculum did not prepare students to apply mathematics in real life. Students who were learning set theory, many parents said, still could not prepare a bill, balance a checkbook, or make change. The cause was little helped by some of the commercial adaptations of the original reform materials, adaptations that simply added a chapter in the back on the "new math" or superficially introduced its language and notation without changing the rest of the textbook. Also, evidence about whether students were learning mathematical principles any better was inconclusive (Massell, 1994a).

Such complaints helped prompt the widespread abandonment of the "new math," but more influential was the fact that the public policy agenda shifted from improving the academic quality of science and mathematics instruction to the equalization of educational opportunity. As Shaftarzick states (1979, pp. 6-7): "Growing concern about the special educational needs of minorities, the disadvantaged, the handicapped, and other segments of the population replaced the previous decade's anxiety about the nation's scientific and technical weaknesses. The Elementary and Secondary Education Act (ESEA) of 1965 officially signaled this shift." School districts started buying traditional mathematics textbooks again, and state tests changed accordingly. The "new math" had no strong constituency within the school system, other than the developers and funders. By the late 1970s there was little residue from what had been a remarkably aggressive national effort at curriculum reform (Dow, 1991).

The role of the federal government in support of innovative curricula had changed dramatically by the late 1970s as well. Two decades earlier, federal agencies had begun work in this area in response to concerns that existing curricular offerings were outdated, dull, inaccurate, and lacking in diversity. But Congress temporarily eliminated the federal role in curriculum development as a result of a debate in 1975 over a federally supported anthropology curriculum, Man: *A* Course of *Study*. This curriculum was lambasted by critics as a federal effort to interfere with local education priorities by encouraging students to think in ways counter to traditional values and patriotic beliefs.

The federal role in mathematics and science curriculum development, however, has been reinstated over the course of the last dozen years. Today, the public debate over curriculum issues in science and mathematics, as well as other subject areas, is even more intense. Many voices can be heard complaining that scholars and experts are trying to impose their cosmopolitan and secular values on students through curricular reform. Clashes such as those over AIDS education and whether to teach "creation science" have highlighted the deep values conflicts embedded in these complex disputes. Still other conflicts have grown out of events such as court decisions favoring bilingual education and out of changes in public sentiment, such as the rise of the women's movement (Fuhrman, 1993). The current debates and contradictory policies on affirmative action further illustrate the disparate views on educational goals that are held by various sections of the U.S. populace.

Maintaining Mathematics and Science Content Standards

Three main areas of political tension make it difficult to develop a supportive coalition, inside the school and outside, for new and different standards in mathematics and science education.

1. Maintaining Leadership while Gaining Consensus. The ill-fated "new math" curriculum was criticized, in part, because parents, teachers, community leaders, administrators, and others at the local level had little or no involvement in its implementation. As the curriculum reform moved into elementary school, teachers were ill-prepared to deal with the changes they were expected to make and hard put to defend "new math" against challenges raised at the local level, particularly when given confusing textbooks from which they were expected to teach. Today, most of the projects engaged in developing content standards for mathematics and science try to avoid these

problems by engaging in a broad process of review and feedback, bringing professional educators, parents, community members, and other interested groups, as well as experts in the discipline, into the process.

But simply gathering input from various constituencies will not develop leading-edge content standards. In fact, achieving such standards is often at odds with building consensus. Tough decisions, which may not be universally popular, often need to be made. If different groups bring deeply held and conflicting beliefs to the table, and if no one demonstrates much willingness to compromise these beliefs in any way, someone will leave the table disappointed, if not downright angry.

Many groups have tried to develop consensus around content standards in their field. The National Council of Teachers of Mathematics (NCTM)., the first group to publish national standards, has been reasonably successful in this effort (Ball, 1992). According to an extensive case study of the development of the mathematics standards (McLeod et al., 1996), officials of NCTM and outside observers cite numerous reasons for the group's success, including:

A great deal of preparation time to develop the intellectual groundwork for mathematics reform.
Broad involvement in the development process, including significant roles for educators and subject-matter specialists.
A far-reaching review and feedback process.
An effective and wide-spread dissemination campaign.
An ongoing series of publications keeping the mathematics standards in the news.
Continued, robust efforts to establish consensus and build capacity, even after standards publications are completed.

This is not, however, a simple "recipe for success" in developing mathematics and science content standards. For despite the apparent success of the NCTM standards, opposition is building both among sectors of the mathematics community and in some affluent school districts with active parents. Critics attack the mathematics standards for permitting the use of calculators, for example, or for not providing enough training in logic or accuracy. Educators continue to debate issues relevant to the NCTM standards, such as how old students need to be to grasp certain concepts and the role of symbol manipulation in learning mathematics (Massell, 1994a).

Also, mathematics is not as diverse a discipline as science. The different mathematical disciplines share a common vocabulary and concept base, which provide a common language for curriculum discussions and consensus-building. In addition, while there may be dissension within the mathematics community and among parents about what kind of mathematics should be emphasized, there are few pressing social or political concerns associated with the mathematics curriculum, while science is rife with controversial issues.

As content standards have become the lead policy instrument in systemic reform, the political climate has put more pressure on the creators of content standards, while giving them less time to work. NCTM was able to spend seven years or more achieving initial consensus on its standards,

but the governors have committed their states to developing standards and assessments within two years, albeit there are now generally (if not universally) accepted nationally developed standards in both science and mathematics to serve as models for the states. The development of assessments consonant with the goals of the national standards lags far behind, however.

The new standards in mathematics and science education present educators with many new challenges, aside from the paucity of appropriate curricular materials and assessment instruments. Stressing inquiry-based learning and openness to innovation, they seek to make teachers more active decision-makers on curriculum. Further, the new standards challenge teachers to teach in ways that they themselves may never have experienced. They also require considerable subject-matter knowledge on part of the teachers, who are expected to become less dependent on the textbook for their instruction. Clearly the nationally developed mathematics and science education standards represent leadership by the professions, and clearly attention has been given to building political consensus. But achieving political consensus in face of the considerable implementation hurdles remains a challenging goal.

2. The Tension Between Flexible and Specific Standards. Today, more than ever, individuals and groups are rebelling against what they see as. too much central control over what happens in schools-whether emanating from the federal, state or district level. Those seeking to create content standards must therefore allow enough flexibility so that local educators and communities still feel they control what goes on in their classrooms. Often, state and national groups end up setting broad goals, such as defining what it means for students to be thoughtful, responsible, competent citizens, while leaving schools and local education agencies to decide how those goals should be met. In other words, the standards offer guidance and direction, but no endorsement of curriculum or teaching specifics (Massell, 1994b). One of the reasons that the NCTM mathematics standards were so readily accepted by mathematics educators is that the ***Curriculum and Evaluation Standards*** were written at the right "grain" size-neither too general nor too specific (McLeod et al., 1996).

However, frameworks and sets of standards can be so broad and shallow that they are devoid of emphasis on in-depth learning of key concepts. Textbook publishers thus feel little pressure to develop high-quality materials, and as a result, the new standards have little impact in the classroom. Vagueness also makes it hard for schools, teachers, and districts to interpret and implement standards, since frequently they cannot even decide what the standards mean. Yet, overspecification leads to our currently overcrowded curriculum that emphasizes coverage at the expense of understanding-in stark contrast with the curricula of many other countries, as recent curriculum analyses done in connection with the Third International Mathematics and Science Study (TIMSS) have demonstrated (Schmidt, McKnight, & Raizen, 1997).

The vagueness of many standards documents leads to three central questions: At what point do standards become so flexible that they no longer provide leadership? Should groups seeking to improve curriculum adopt standards that some people will dislike? Or should they be willing to compromise their standards in order to survive politically? Ideally, a certain level of detail is needed to guide other parts of the system including assessments, but finding that level, and winning consensus around it, can be difficult (Kirst, 1994).

3. The Tension Between Up-To-Date, Dynamic Standards and Reasonable Expectations for Change in the System. How often should mathematics and science content standards be revised? What should be the process for revision? Who should decide? Content standards are not something that should be set and fixed for all time. What is known about mathematics and science expands and changes, sometimes quickly and dramatically. Implications for K- 12 education need to be considered, yet the school curriculum shows great stability; for example, school physics continues almost exclusively to be nineteenth-century physics. Also, through experience with content standards, revisions are needed for purposes of clarity. Increasingly, content standards include standards about teaching and assessment, and best practices in these areas are continually evolving as well.

But frequent revisions to content standards are not practical. The process of developing and disseminating new standards is difficult. The implementation of the standards also takes time. Further, revisions in standards require revisions in other parts of the system. California, for example, has been criticized for having new frameworks and assessments ready before staff development and curriculum materials had caught up with what was to be taught and learned. Revised standards do nothing to help educate our students if our educational resources and systems cannot keep up with them.

Revised content standards create a special challenge for assessment. A key goal for assessment is to describe changes in level of student accomplishment over time. But when content standards are revised, assessments must also be revised to stay aligned with the standards. When assessments change, however, equating to earlier assessments becomes problematic. Is it better to have stable standards and assessments so change in student achievement can be monitored? Or is it better to have dynamic standards that reflect new priorities and new understandings? Over time, it is possible to establish new baselines, as the National Assessment of Educational Progress (NAEP) has done with the 1996 science assessment, but this is not feasible if standards change too frequently.

Conclusion

Content standards for mathematics and science are seen, by policymakers and educators to be crucial components of the overall vision of systemic reform. (An examination of state frameworks carried out by SRI in 1996 has questioned, however, whether these documents lead or follow reform.) Content standards can provide referents for subsequent state and local alignment of textbooks, assessment, staff development, categorical programs, and accreditation. And alignment of all these policy areas, linked to rigorous standards, is conceived to be the cornerstone of systemic reform (O'Day & Smith, 1993).

This paper has argued that

- Winning broad support for content standards is a difficult and inherently political process, in which conflicts will arise.

- For the mathematics and science curriculum, "key players" in this political process will include professional associations in mathematics and science education and in mathematics and science.

Further guidance is provided in the National Governors' Association publication ***Transforming Education: Overcoming Barriers*** (David & Goren, 1993). Among the guidelines in the NGA document are the need to:

- Send clear and consistent policy signals and remove policies inconsistent with systemic reform.

- Balance top-down and bottom-up strategies and make mid-course corrections.

The NGA document also stresses the importance of viewing education as a public good and the critical role of public schools in our democracy. Shared efforts at improvement should displace the current mode of emphasizing school shortcomings. As an important component of improvement, professional development should be given priority and become an ongoing part of the job of teaching.

The guidelines in the NGA publication, offered for governors pursuing systemic education reform, provide insight for educators and policymakers at all levels who want to make the development and implementation of mathematics and science content standards a cornerstone of educational improvement.

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